FRESHWATER FROM SEAWATER

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1. Introduction

Currently the main desalination processes are thermal desalination and reverse osmosis (RO). Desalination by reverse osmosis (RO) is costly but so is the transportation of liquid freshwater. There is a pressing need to minimize the total cost of seawater conversion to freshwater and transportation to irrigate inland such as the deserts in Israel and Saudi Arabia. A dual fuel cells desalination system is a cost effective alternative.

2. Methods

2.1. *Reverse osmosis*

The following plan view illustrates a RO plant.

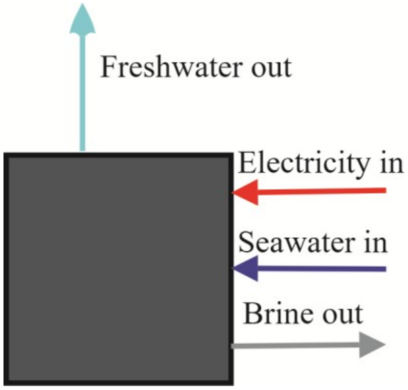

Fig. 1 Reverse Osmosis Schema

The system inputs electricity and seawater; it outputs brine and freshwater.

2.2. *Dual fuel cell*

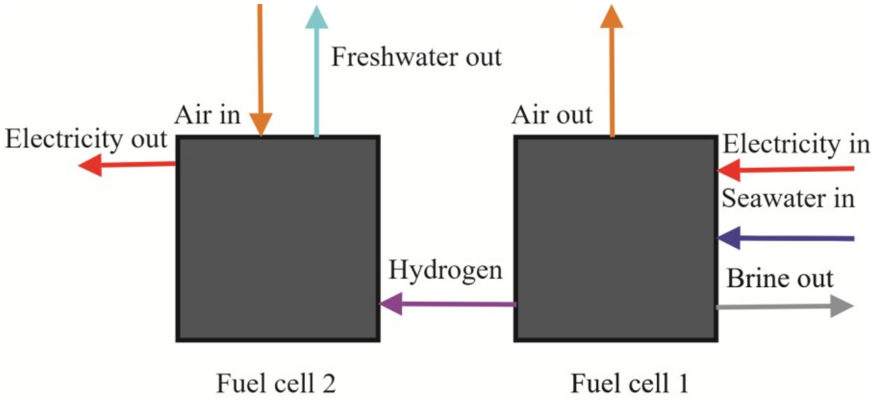

Fig.2 is a Dual Fuel Cells Desalination Schema

A proton exchange membrane (PEM) fuel cell is a well-known electrolysis technology that uses electricity to split water into its components. Fuel cell 1inputs electricity and seawater; it outputs oxygen, brine and hydrogen. The hydrogen in gaseous form is piped to fuel cell 2; there can be many secondary fuel cells. Fuel cell 2 uses oxygen in the air and the piped in hydrogen to reform water, and to produce direct current electricity, reducing the total energy required by this system.

To produce 1kg of hydrogen from water, according to William Mook, assisted by Bob Laughlin Energy & Aerospace and Aeronautical Engineering, Stanford University[1] requires this amount of electricity:

"So, water consists of two hydrogen atoms and one oxygen atom, totaling 18 amu. One mole of water totals 18 grams. To break this down into 2 grams of hydrogen and 16 grams of oxygen requires 335 kJ. That's 18.6 MJ/litre of water. Or 5.2 kWh/litre. Each litre produces 125 grams of hydrogen. So, to produce 1 kg of hydrogen requires 8 litres of water and 41.4 kWh/kg hydrogen. That's 149 MJ/kg hydrogen. Hydrogen contains 141.8 MJ/kg of energy. So, this is quite efficient." That is 95% efficiency.

The second fuel cell produces electricity and according to The Engineer's toolbox[2] the Higher Heating Value (HHV) of gas hydrogen is 142.2 MJ/kg or 39.5 kWh.

The net energy consumption of the system is 2 kWh — (41.4 – 39.5). Reverse osmosis on the other hand requires between 3 to 7 kWh/m3.[3]

3. Cost comparison

3.1. Capital costs

The present analysis doesn't take into account the cost of capital.

Many companies build fuel cells, some shipped by containers. Glass Reinforced Plastic pipelines are well adapted to pipe hydrogen gas. These well-known technologies can be applied with little research costs.

3.2. Operating costs

The present study only compares the energy required to run this system.

As shown above, the Dual Fuel Cells system is cheaper than RO to convert seawater to freshwater.

According to the Engineer Toolbox[4] the transportation operating cost of water is:

10 US gpm is lifted 10 ft. The electricity cost is 0.1 USD/kWh and the pump and motor efficiency 90% (0.9). The cost per hour is

C = 0.746 (10 US gpm) (10 ft) (0.1 USD/kWh) / (3960 0.9 0.9)
= 0.002 USD/hour per gallon

Eugene Karangwa's *Estimating the Cost of Pipeline Transportation in Canada*[5] states: "As pipelines allow transporting very large quantities of gas and oil on very long distances the unit cost of this transportation activity is very low, almost zero as it is displayed in Table 6. For the gas pipeline transportation sector the unit cost per cubic metre-kilometre is $0.00006 in the base scenario."

4. Conclusion

The dual fuel cell desalination system is economical. It can become particularly suitable to provide freshwater to areas that are far away from the sea.

5. References

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[1] https://www.quora.com/How-much-electricity-is-needed-to-produce-hydrogen-from-water

[2] https://www.engineeringtoolbox.com/fossil-fuels-energy-content-d_1298.html

[3] https://www.quora.com/What-is-the-power-requirement-of-a-typical-reverse-osmosis-water-filter-per-hour

[4] https://www.engineeringtoolbox.com/water-pumping-costs-d_1527.html

[5] https://ctrf.ca/wp-content/uploads/2014/07/Karangwa2008.pdf